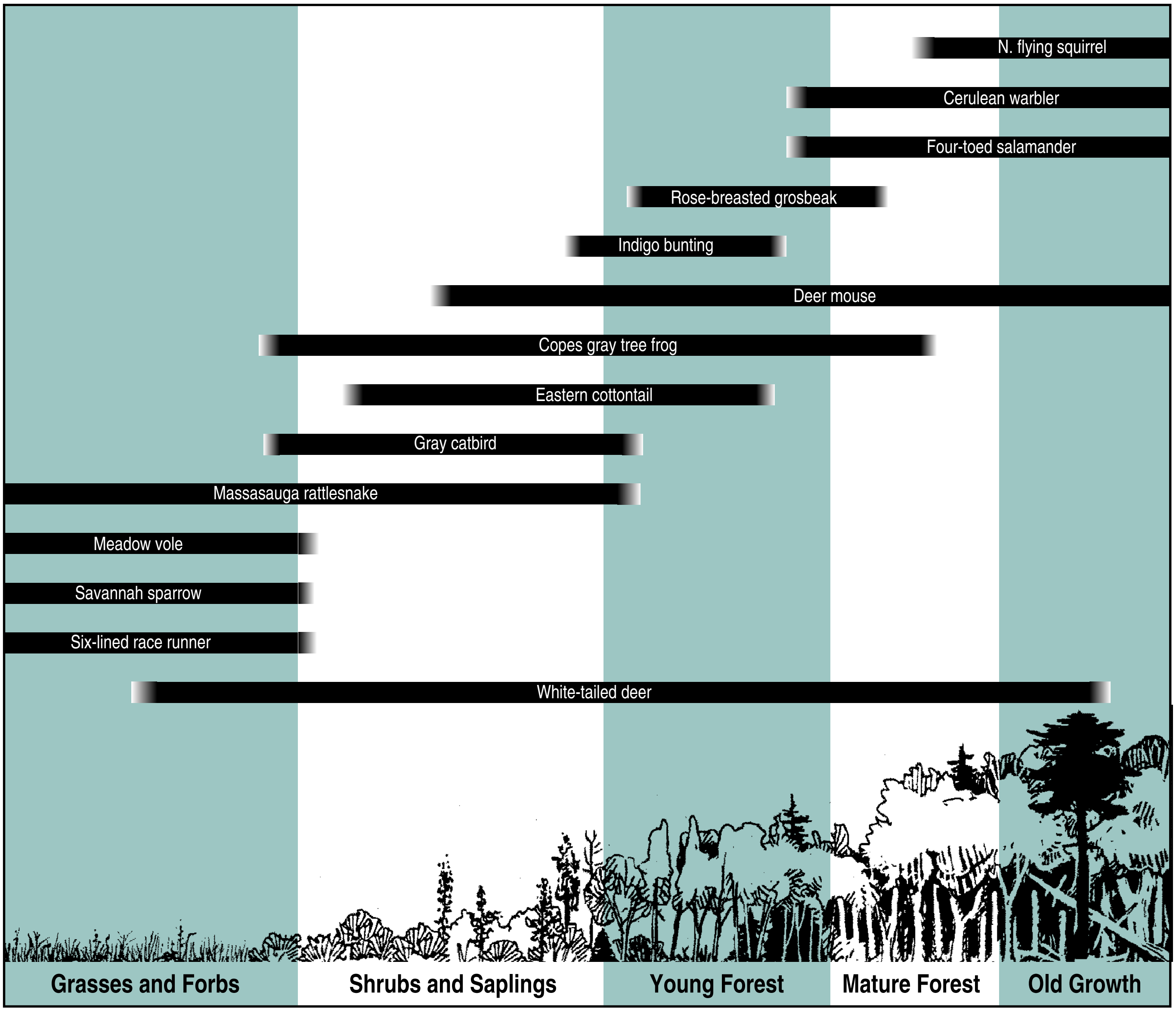

Figure 4

Examples of temporal scale can be observed with the succession of a southern Wisconsin grassland to a forest. The composition of plant and animal communities change along with the landscape. Adapted with permission from material produced by the Minnesota Department of Natural Resources.

Ecological Simplification

Ecological simplification means that the interrelationships between organisms and their environments are reduced in number and complexity. Simplification can be caused by habitat loss, non-native species encroachment, air and water pollution, and many other factors. Although the effects of simplification are complicated and often subtle, they are often discussed in terms of their impact on the three major attributes of ecosystems: *composition, structure*, and *function* (Fig. 5).

Composition

Composition refers to the fundamental elements of natural systems—the specific organisms or groups of organisms that a unit area or geographic area contains. At the statewide level it includes ecosystems, communities, species, and their genetic composition. Thus, an ecological system simplified in terms of composition might have reduced numbers of species present or a limited gene pool for a remnant or isolated species.

The most radical impacts on composition occur when there is total destruction of the biotic, abiotic, spatial, or temporal needs of species. The conversion of native prairies, savannas, wetlands, and southern forests to agriculture and urban development since Euro-American settlement are among the most conspicuous examples.

The introduction of exotic species provides another example. Purple loosestrife, known to exist in restricted areas of Wisconsin's wilds for over 40 years, has spread across three-quarters of the state in ten years, seriously simplifying many wetlands. Garlic mustard has invaded southern Wisconsin forests, displacing native forbs and dependent fauna. Common buckthorn and Japanese honeysuckle have invaded southern mesic and dry mesic forests, while glossy buckthorn has invaded wet forests and bogs. All three have displaced forbs and shrubs, and in bogs even established trees are being lost to competition. In some southern Wisconsin oak forests, buckthorn and honeysuckle encroachment has begun to significantly reduce oak regeneration. Similarly, the rusty crayfish, introduced as sport-fishing bait, has spread to a large number of inland lakes, displacing native crayfish and disrupting entire plant communities. The result has been an adverse impact on other fauna such as fish, invertebrates, and zooplankton that are dependent upon the aquatic macrophytes consumed by the rusty crayfish.

> When ecosystems are simplified, we may observe a reduction in species numbers, their gene pools, the physical structure of their habitats, or the complexity of life-sustaining processes such as food webs or water cycles.

Thus, the presence of non-native species within terrestrial and aquatic communities and ecosystems often leads to displacement of native species and change in ecosystem function. Displacement is usually not one for one; one exotic species can displace many native species. Because exotics are generally introduced without consideration for natural biological and ecological controls, once they "escape into the wild" they sometimes prove very successful in competing against native species. Today, an estimated 22% of Wisconsin's 2,300 vascular plant species are non-native species.

Structure

Structure refers to the pattern or physical organization of an area; it is used to define physical appearance both vertically and horizontally. Vertical stratification is readily visible in a mesic hardwood forest, where one group of species occupies the canopy layer, another group the subcanopy, another the sapling layer, and so forth, down through shrubs, tall herbs, short herbs, and ground cover (surface) plants. Horizontal variation occurs across the length and breadth of any community or, at a larger scale, across sub-regional and regional landscapes. Canopy gaps, forest

Figure 5

The three major attributes of ecosystems: composition, structure, and function. Ecological simplification occurs in relation to all three.

Composition

The make-up of an ecological unit, including the specific organisms or groups of organisms in a particular area.

Structure

The pattern or physical organization of an area. It has both vertical and horizontal components.

Function

The roles that the living and nonliving components of ecosystems fulfill in driving the processes that sustain ecosystems.

A simplified ecosystem has little of the structural complexity that creates diverse habitat opportunities as a basis for ecosystem function.

openings, seasonal ponds, savanna alternating with prairie, riffles alternating with slow water, and backwaters adjoining main streams are all examples of horizontal variation. The location of vegetation in a horizontal plane is related to the slope, exposure, soil, proximity to other plants of the same or different species, and dispersal mechanisms. Vegetative debris—fallen trees and limbs, standing dead trees, and leaf and forb litter—is also part of a community's horizontal and vertical structure.

Animals follow a pattern of vertical and horizontal organization similar to plants. For example, birds and invertebrates that occupy the canopy of a forest community differ from those that occupy the midlevel, many of which differ from those residing on the forest floor. Similarly, the fauna associated with a lake's emergent vegetation differ from the animals associated with the floating or submerged vegetation.

A simplified ecosystem has little of the structural complexity that creates diverse habitat opportunities as a basis for ecosystem function. For example, a forested area being managed on short rotation for even-age, single-species trees is a structurally simplified system. Because the tree species are all of similar age and are cut before other layers of vegetation can become well established, there is little vertical or horizontal layering. Animal species inhabiting the area would likewise reflect lower diversity than would be found in a forest with trees of various ages.

Function

Function refers to the roles biotic and abiotic components of ecosystems (e.g., producers, consumers, digestors, transformers, water, minerals, and microclimates) fulfill in driving the *ecological processes* (e.g., water and carbon cycles, mineral and nutrient cycles) that sustain the ecosystem. Every naturally occurring organism within an ecosystem has one or more roles in sustaining the dynamics of that ecosystem. For example, on an ecosystem or landscape scale, vegetation controls the community environment, is the primary source of energy for other organisms within the community, and is the principal source of minerals and chemical compounds necessary to sustain animal life. Animals are the main consumers, with primary consumers eating plants and secondary consumers eating other animals. Still other plants and animals along with fungi and bacteria perform essential functions as decomposers and transformers of waste products and detritus, converting dead material back into elements essential to plant growth. Each individual plant and animal has a functional role in the support of other species and the community as a whole.

Increased diversity and functional complexity generally provide resilience to ecosystems. Conversely, for a given ecosystem, reduced biological diversity may result in less resilience. In less biologically diverse systems minor changes in energy flow or population structure produce major changes in energy transfer and populations. Unpredictable and chaotic changes may occur. A community will cease to be part of a viable ecosystem if there is significant functional loss. The Lake Winnebago system provides a good example. An increase in water level in the system and other factors led to a severe reduction in aquatic plant populations beginning in the late 1800s. Wind and wave action across these large expanses of water prevented macrophyte reestablishment by increasing turbidity, eroding the shoreline, and uprooting plants. Populations of invertebrates, fish, and waterfowl have fluctuated through the years with a general trend toward decreasing numbers. Numerous attempts to manage the water level have met with limited success due to the great functional losses to the system. A system-wide approach is now being taken through DNR's Lake Winnebago Comprehensive Management Plan and offers a much better chance for improvement.